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Short Communication

Effect of soy sauce on lipid oxidation of irradiated pork patties

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HIGHLIGHTS

- Antioxidant effect of soy sauce on irradiated pork patties was studied.
- The soy sauce can retard lipid oxidation of the irradiated pork patties.
- A synergistic effect of ascorbic acid for preventing lipid oxidation was observed.

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ABSTRACT

This study was conducted to find out the antioxidant effect of the soy sauce on lipid oxidation of electron beam irradiated pork patties. The pork patties prepared with sodium chloride or soy sauce solution at identical salt concentrations were irradiated at 0 or 5 kGy, and peroxide value, conjugated diene, 2-thiobarbituric acid, and free fatty acid values were evaluated for 10 days (4 °C). The irradiated pork patties treated with soy sauce showed the lowest peroxide value and 2-thiobarbituric acid value at the end of storage compared to those prepared with sodium chloride. The irradiated pork patties formulated with soy sauce and 0.5% ascorbic acid had similar 2-thiobarbituric acid and free fatty acid values compared to those of the non-irradiated pork patties treated with sodium chloride. Our results suggested that the soy sauce can retard the lipid oxidation of irradiated pork patty, and a synergistic effect between soy sauce and ascorbic acid was observed.

1. Introduction

Acceleration of lipid oxidation by irradiation is one of main concern in food irradiation technology. According to Ahn et al. (1998) and Lee and Ahn (2003), lipid oxidation of irradiated meat is affected by the formation of free radicals and depends on irradiation dose level and hydroxyl radicals, which are produced from water within meat and influence the increase in lipid oxidation. Additionally, Ahn et al. (2000) reported that lipid oxidation of aerobic-packaged pork patties irradiated at 4.5 kGy increased as compared to non-irradiated patties on initial day. For these reasons, various efforts have been attempted to reduce lipid oxidation in irradiated meat and meat products, such as addition of antioxidants (Lim et al., 2008) and different packaging methods (Jo et al., 1999). Similarly, Nam and Ahn (2003) reported that antioxidants reduced lipid oxidation of pork patties irradiated at 4.5 kGy and had a significant effect under vacuum packaging.

Soy sauce is a traditional fermented seasoning and has been used as a marinade source in various meat-based cuisines in East Asian countries (Nam et al., 2010; Wang et al., 2007). Generally, the soy sauce contains high salt (approximately 15–20%), water, peptides, free amino acids, organic acids, and free sugars derived from the main ingredients, such as soybean and/or wheat, during fermentation. According to Wang et al. (2007), dark soy sauce has antioxidative, antimicrobial, and antihypertensive activities, and that melanoidin, which is formed by the Maillard reaction during fermentation, is a highly antioxidative compound. The antioxidative effects of soy sauce have been investigated and verified in beef patties (Kim et al., 2011).

Therefore, the aim of this study was (1) to evaluate the effect of soy sauce on lipid oxidation in electron beam irradiated pork patties and (2) to evaluate the synergistic effects between soy sauce and ascorbic acid.

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2. Materials and methods

2.1. Sample preparation

Commercial soy sauce was purchased from a local market. Soy sauce showed pH 4.8 and 16% salt concentration. The soy sauce and sodium chloride solutions were diluted in ice water to a final salt concentration of 10% (w/w). Pork ham and back fat were obtained from a local market, separately ground and mixed with each curing solution. Pork patties were composed by 60% ground pork, 20% ground back fat, and 20% curing solution. To determine synergistic effects of soy sauce and ascorbic acid, 0.5% ascorbic acid was added. The mixed pork patties were processed into 80 ± 1 g patties with 100 mm in diameter and 10 mm below in thickness using patty presses. Each pork patty was placed in oxygen-permeable nylon/polyethylene bags (20×30 cm^2), aerobic-packaged, using a packaging system. The packaged samples were stored at −20 °C for 12 h to maintain shape of pork patties and were transferred at 4 °C. After 24 h of manufacturing, the packaged samples excluding control group were irradiated.

2.2. Electron beam irradiation

Electron beam irradiation was performed with a linear electron beam accelerator (2.5 MeV) at 4 ± 1 °C. The target dose of pork patties was 5 kGy at 1 MeV using about 90 kGy/min. The absorbed irradiation dose was measured by using a cellulose triacetate dosimeter that was attached to the surface at the top and bottom of each packaged pork patty (ASTM, 2000). The max/min ratio was 1.09. The irradiated samples were transferred to a 4 °C refrigerator, and stored for 10 days.

2.3. Lipid extraction

Total lipids were extracted from samples as described by the method of Folch et al. (1957) by using the chloroform and methanol solvent system (the ratio of 2:1).

2.4. Peroxide value

The peroxide value of the lipid extracted by Folch method was measured by AOAC (1995).

2.5. Conjugated dienes value

The formation and alteration of conjugated dienes was determined as described by Sirinivasan et al. (1996).

2.6. 2-Thiobarbituric acid value

Lipid oxidation of irradiated pork patties was assessed in triplicate by the TBA method of Tarladgis et al. (1960) with minor modifications.

2.7. Free fatty acid values

The acid values of the lipid extracted from the samples were measured to determine formation of free fatty acid, the percentage of free fatty acids was calculated based on oleic acid (AOCS, 2003; Hasenhuettl, 2008).

3. Results and discussion

The changes in peroxide values (POV) of irradiated pork patties were not affected by the curing solution or irradiation immediately after irradiation, and the increase in POV depended upon storage time. Irradiated pork patties made with sodium chloride solution had a higher POV than pork patties prepared with soy sauce at final storage days, regardless of irradiation (data not shown).

Conjugated dienes (CD) formation is associated with lipid oxidation at the initial stages of storage (Kulas and Ackman, 2001; Prasetyo et al., 2008). On day 0, the CD values of the irradiated pork patties varied from 0.567 to 0.582 nmol/mg meat. The CD values of all treatments increased until day 3, when the irradiated pork patties formulated with sodium chloride solution had higher CD values than those in patties prepared with soy sauce (Fig. 1). CD values in all treatments decreased at the final storage time. However, no differences in CD values were observed on each storage day among treatments. This result indicates that electron beam irradiation and soy sauce had no effect on the CD values of pork patties.

2-Thiobarbituric acid (TBA) values are mainly used to assess lipid oxidation in meat and meat products. The effects of soy sauce on TBA values of electron beam irradiated pork patties are shown in Fig. 2. The irradiated pork patties had a higher TBA value on day 0 compared to that of the control regardless of adding soy sauce. TBA values in each treatment increased continually with storage time, and the highest TBA values were observed at the end of storage. The irradiated pork patties made with sodium chloride

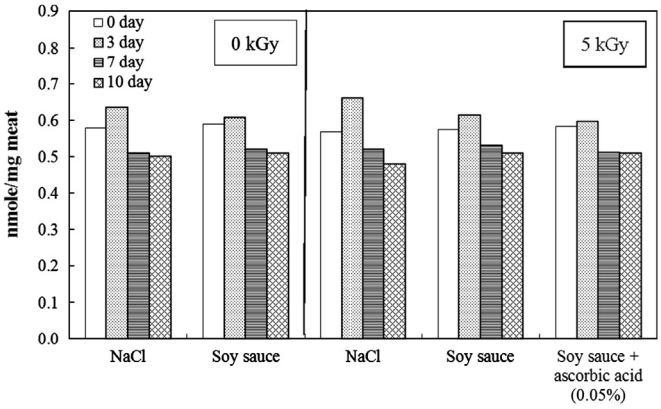

Fig. 1. The effect of soy sauce on conjugated dienes (CD) value of electron beam irradiated pork patties during chilled storage (4 °C). Salt concentration of all curing solutions was equal as 10% (w/v).

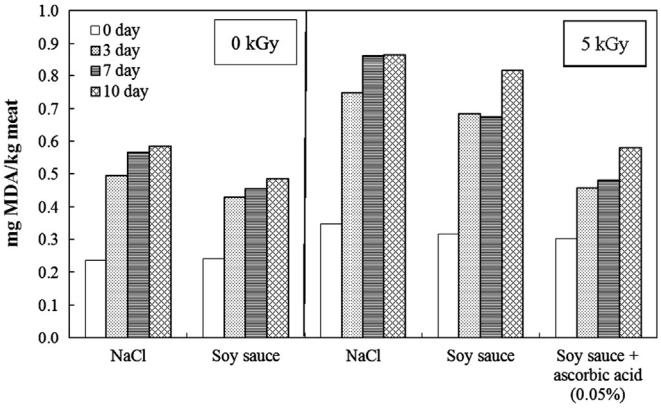

Fig. 2. The effect of soy sauce on 2-thiobarbituric acid value (TBA) of electron beam irradiated pork patties during chilled storage (4 °C). Salt concentration of all curing solutions was equal as 10% (w/v).

solution had the highest TBA values among all treatments at the end of storage. Similar TBA values were obtained between non-irradiated pork patties formulated with sodium chloride and irradiated pork patties treated with soy sauce and ascorbic acid, in which were 0.584 and 0.581 mg MDA/kg meat, respectively. According to Wang et al. (2007), melanoidin in soy sauce has antioxidative effects due to the hydroxyl and amine groups, and soy sauce also contains isoflavone and flavonoids, which are antioxidants derived from soybean (Moon and Cheigh, 1987). Thus, our results showed that soy sauce inhibited lipid oxidation after irradiation, and that the combined use of soy sauce and ascorbic acid is an effective method to retard lipid oxidation by irradiation.

The formation of free fatty acid (FFA) is associated with the decomposition of lipids hydrolyzed by endogenous lipolytic enzymes (Park et al., 2008). The results showed that irradiated pork patties made with soy sauce had a higher FFA values than those in the non-irradiated pork patties prepared with sodium chloride at the beginning of storage. Soy sauce includes organic acids such as acetic acid, butyric acid, lactic acid, and pyroglutamic acid (Choi et al., 2000). The FFA values of all treatments increased with increasing storage time, and the highest FFA value was obtained in the non-irradiated pork patties prepared with sodium chloride (data not shown).

4. Conclusion

Soy sauce can retard lipid oxidation after irradiation in electron beam irradiated pork patties during chilled storage. In addition, the synergistic effects of soy sauce and ascorbic acid on lipid oxidation were observed.

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